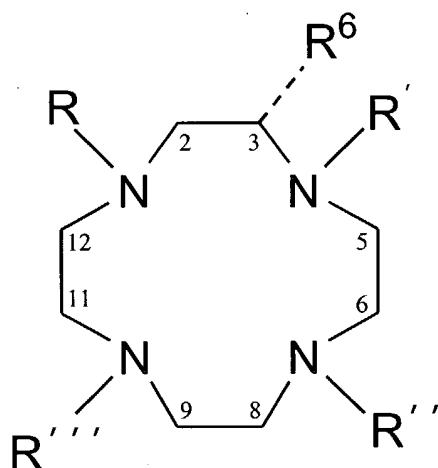


WHAT IS CLAIMED IS:

1. A magnetic resonance contrast agent comprising:
 - 2 a tetraazacyclododecane ligand having a general structural
 - 3 formula as follows:



- 4
- 5 and comprising a macrocyclic ring and wherein pendant arms
- 6 R, R', R'' and R''' attached to a ring nitrogen have the general
- 7 formula: $-C'HR^1R^2$ and for three or more of said pendant arms a
- 8 chirality of said carbon atoms C' are identical for each of said
- 9 three or more pendant arms, said R^1 are groups larger than
- 10 hydrogen, and said R^2 is selected from the group consisting of:
 - 11 an alcohol ($-\text{CH}_2\text{OH}$);
 - 12 amides ($-\text{CONR}^3\text{R}^4$, where R^3 and R^4 are organic groups);
 - 13 a carboxylate ($-\text{COOH}$);

14 phosphinates ($-\text{PO}_2\text{HR}^5$, where R^5 is an organic group);
15 and
16 a phosphonate ($-\text{PO}(\text{OH})_2$); and
17 wherein one or more of substituents R^6 is a group larger
18 than a methyl group and is located on one or more ring carbons;
19 and
20 a paramagnetic metal ion coordinated to said
21 tetraazacyclododecane ligand.

2. The magnetic resonance contrast agent as recited
2 in Claim 1, wherein said chirality of said carbon atoms C'
3 provides said three or more of said pendant arms with a Λ or
4 Δ orientation, and wherein a chirality of a ring carbon bonded to
5 said one or more of substituents R^6 provides said macrocyclic
6 ring with an identical orientation, $\lambda\lambda\lambda\lambda$ or $\delta\delta\delta\delta$, respectively,
7 said tetraazacyclododecane ligand thereby having a monocapped
8 twisted square antiprism coordination geometry.

3. The magnetic resonance contrast agent as recited
2 in Claim 2, wherein said R^2 group is said alcohol or amide, and
3 further including a water molecule associated with said
4 tetraazacyclododecane ligand and said paramagnetic metal ion,
5 said water molecule having a residence lifetime at about 298°K,

6 τ_M^{298} , of between about 1 and about 100 microseconds.

4. The magnetic resonance contrast agent as recited
2 in Claim 2, wherein said R^2 group is said carboxylate, and
3 further including a water molecule associated with said
4 tetraazacyclododecane ligand and said paramagnetic metal ion,
5 said water molecule having a residence lifetime at about 298°K,
6 τ_M^{298} , of between about 10 and about 100 nanoseconds.

5. The magnetic resonance contrast agent as recited
2 in Claim 1, wherein said chirality of said carbon atoms C'
3 is controlled to provide said three or more of said pendant arms
4 with a Δ or Λ orientation, and wherein a chirality of a ring
5 carbon bonded to said one or more of substituents R^6 provides
6 said macrocyclic ring with an opposite orientation, $\lambda\lambda\lambda\lambda$ or $\delta\delta\delta\delta$,
7 respectively, said tetraazacyclododecane ligand thereby having a
8 monocapped square antiprism coordination geometry.

6. The magnetic resonance contrast agent as recited
2 in Claim 5, wherein said R^2 group is said alcohol or amide, and
3 further including a water molecule associated with said
4 tetraazacyclododecane ligand and said paramagnetic metal ion,
5 said water molecule having a residence lifetime at about 298°K,

6 τ_M^{298} , of between about 10 and about 5000 microseconds.

7. The magnetic resonance contrast agent as recited
2 in Claim 5, wherein said R^2 group is said carboxylate, and
3 further including a water molecule associated with said
4 tetraazacyclododecane ligand and said paramagnetic metal ion,
5 said water molecule having a residence lifetime at about 298°K,
6 τ_M^{298} , of between about 100 and about 500 nanoseconds.

8. The magnetic resonance contrast agent as recited
2 in Claim 5, wherein said R^2 group is said phosphonate or said
3 phosphinate, and further including a water molecule associated
4 with said tetraazacyclododecane ligand and said paramagnetic
5 metal ion, said water molecule having a residence lifetime at
6 about 298°K, τ_M^{298} , of between about 10 and about 100 nanoseconds.

9. The magnetic resonance contrast agent as recited
2 in Claim 1, wherein said R^1 is a methyl group, said R^2 is said
3 carboxylate, and said R^6 is a para-aminobenzyl group and said
4 paramagnetic metal ion is Gd^{3+} .

10. The magnetic resonance contrast agent as recited
2 in Claim 10, further including a water molecule associated

3 with said tetraazacyclododecane ligand said water molecule
4 having residence lifetime at about 298°K, τ_M^{298} , of about 15
5 nanoseconds.

11. The magnetic resonance contrast agent as recited
2 in Claim 1, wherein at least one of said one or more of
3 substituents R^6 include a functional group selected from the
4 group consisting of:

5 amino groups;

6 carboxylates;

7 isothiocyanates; and

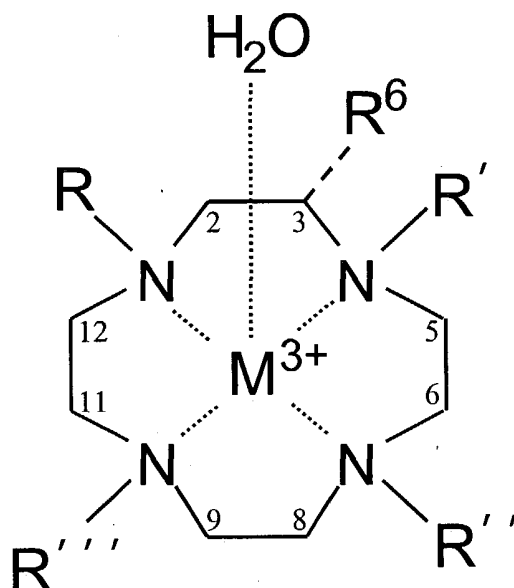
8 maleimides; and

9 a carrier component conjugated to said functional group.

12. The magnetic resonance contrast agent as recited
2 in Claim 1, wherein said paramagnetic metal is a lanthanide ion.

13. A method of using a magnetic resonance contrast agent, comprising:

subjecting a contrast agent contained within a sample to a radio frequency pulse wherein said contrast agent is a tetraazacyclododecane ligand having a general formula of:



and comprising a macrocyclic ring and wherein pendant arms R, R', R'' and R''' attached to a ring nitrogen have the general formula: $-C'HR^1R^2$ and for three or more of said pendant arms a chirality of said carbon atoms C' are identical for each of said three or more pendant arms, said R¹ are groups larger than hydrogen, and said R² is selected from the group consisting of:

an alcohol ($-\text{CH}_2\text{OH}$);

amides ($-\text{CONR}^3\text{R}^4$, where R³ and R⁴ are organic groups);

15 a carboxylate (-COOH);
16 phosphinates (-PO₂HR⁵, where R⁵ is an organic group);
17 and
18 a phosphonate (-PO(OH)₂); and
19 wherein one or more of substituents R⁶ is a group larger than a
20 methyl group and is located on one or more ring carbons; and
21 wherein said tetraazacyclododecane ligand further includes a
22 paramagnetic metal ion (M³⁺) coordinated to said
23 tetraazacyclododecane ligand and a water molecule (H₂O)
24 associated with said tetraazacyclododecane ligand; and
25 obtaining a magnetic resonance signal by applying a radio
26 frequency pulse at about a resonance frequency of water.

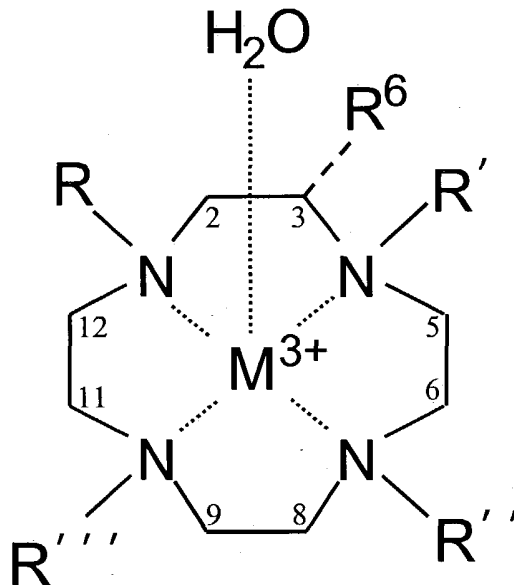
14. The method as recited in Claim 13, further includes
2 producing a magnetic resonance image from said magnetic
3 resonance signal.

15. The method as recited in Claim 13, wherein said
2 contrast agent further includes a carrier component conjugated
3 to said one or more of substituents R⁶.

16. The method as recited in Claim 15, wherein
2 said water molecule has a relaxivity at 298°C, r₁²⁹⁸, of at least
3 about 50 mM⁻¹ s⁻¹.

17. A magnetic resonance system, comprising:

a magnetic resonance contrast agent, wherein said magnetic resonance contrast agent includes a tetraazacyclododecane ligand, having a general formula of:



and comprising a macrocyclic ring and wherein pendant arms R, R', R'' and R''' attached to a ring nitrogen have the general formula: $-C'HR^1R^2$ and for three or more of said pendant arms a chirality of said carbon atoms C' are identical for each of said three or more pendant arms, said R^1 are groups larger than hydrogen, and said R^2 is selected from the group consisting of:

an alcohol ($-\text{CH}_2\text{OH}$);

amides ($-\text{CONR}^3\text{R}^4$, where R^3 and R^4 are organic groups);

a carboxylate ($-\text{COOH}$);

15 phosphinates ($-\text{PO}_2\text{HR}^5$, where R^5 is an organic group);
16 and
17 a phosphonate ($-\text{PO}(\text{OH})_2$); and
18 wherein one or more of substituents R^6 is a group larger
19 than a methyl group and is located on one or more ring carbons;
20 and wherein said tetraazacyclododecane ligand further includes a
21 paramagnetic metal ion (M^{3+}) coordinated to said
22 tetraazacyclododecane ligand and a water molecule (H_2O)
23 associated with said tetraazacyclododecane ligand, wherein said
24 magnetic resonance contrast agent produces a magnetic resonance
25 signal when subjected to a radio-frequency pulse; and
26 a magnetic resonance apparatus configured to produce said
27 radio-frequency pulse.

18. The magnetic resonance system recited in Claim 17,
2 further comprising a sample that is a living subject and
3 said sample contains said magnetic resonance contrast agent.

19. The magnetic resonance system recited in Claim 17,
2 wherein said magnetic resonance apparatus produces a image of
3 said sample from said magnetic resonance signal.

20. The magnetic resonance system recited in Claim 17,
2 wherein said magnetic resonance contrast agent further includes

3 a carrier component conjugated to said one or more of
4 substituents R^6 and said water molecule has a relaxivity at
5 298°C , r_1^{298} , of at least about $50 \text{ mM}^{-1} \text{ s}^{-1}$.